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HETA 94-0300-2528
Cape May County Board of Taxation
Cape May Court House, New Jersey

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PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer and authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

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ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by C. Eugene Moss, H.P., C.S.S. and Moustafa Ragab, M.D., of the Hazard Evaluations and Technical Assistance Branch, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Desktop publishing by Ellen E. Blythe.

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Health Hazard Evaluation Report 94-0300-2528
Cape May County Board of Taxation
Cape May County House, New Jersey
September 1995

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SUMMARY

In May 1994, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation (HHE) at the Cape May County Board of Taxation (CMCBT) in Cape May Court House, New Jersey. The request was submitted by the County Tax Administrator due to health problems among four CMCBT employees who had suspected high occupational exposure to extremely low frequency (ELF) electric and magnetic fields in the building.

On September 15-16, 1994, a site visit was conducted to measure ELF electric and magnetic fields at the building and interview workers about health problems. Emphasis was placed in making measurements near four large switchboards located directly behind the back wall of the Tax Office. Magnetic and electric field levels at the outside corners of the building and in the parking lot ranged

from 0.1 to 10.7 milligauss (mG), and 1.9 to 6.9 volts per meter (V/m), respectively. Levels ranging from 0.1 to 900 mG and 1.4 to 5.7 V/m were found in the facility. Average magnetic field level measurements made on all four administrative workers ranged from 3.02 to 33.55 mG. Measurements made by NIOSH, which were similar to prior results obtained by the local electrical utility company, indicated that the back area of the Tax Office had the highest ELF fields.

The medical interviews revealed that two of the four workers reported non-malignant breast related problems. The remaining two workers reported thyroid conditions and an abnormal cervical pap smear test. The four workers had diverse, unrelated medical problems, none of which has been found in published studies to be associated with exposure to ELF.

The measurement data suggests, that on the days of evaluations, the range of ELF electric and magnetic fields measured outside the CMCBT building are generally low, the fields inside are approximately the same magnitude measured previously by the electrical utility company and by one of the affected workers, the magnetic fields levels in the back area of the Tax Office are at the higher end of the exposure level range documented in previous NIOSH office evaluations, and all levels were below current occupational exposure limits. The back area of the Tax Office, located next to the utility room, had more exposure than other areas due to four switchboards. It was not possible in this evaluation to determine if any of the reported health problems were associated with ELF exposures at the CMCBT facility.

KEYWORDS: SIC 7389 (Tax collection agencies collecting for a city, county, or state) extremely low frequency, ELF, electromagnetic field, EMF.

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INTRODUCTION

In May 1994, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation (HHE) at the Cape May County Board of Taxation (CMCBT) building in Cape May Court House, New Jersey, because of concerns about health effects from exposure to electric and magnetic fields in the building. A NIOSH field investigation was conducted at the CMCBT building on September 15–16, 1994, to measure both extremely low frequency (ELF) fields and interview workers.

BACKGROUND

Figure 1 is a schematic diagram of the one-story CMCBT building that shows the location of the electrical switching units, Tax Office, and Hall of Records. On the days of measurement, the Tax Office, built in 1986, had four employees. The Tax Office consisted of three sections, a front area used to greet visitors, a middle area used for records review, and a back area which contained a conference/work room. Immediately behind the back rear wall of the Tax Office was the utility room that contained four General Electric AV-LINE™ Switchboards located approximately one meter from the north wall in a line parallel to the back wall. These switchboards had been installed in early 1993 and were considered by Tax Office workers to be the source of the ELF fields of concern.

Due to possible health effects from exposure to electric and magnetic fields in the work area, one of the employees of the Tax Office purchased a magnetic field meter and had recorded field levels over several months. In addition, the workers had requested the local utility company to make measurements at least twice during the time it took to install the switchboards.

EVALUATION CRITERIA

At the present time, there are no Occupational Safety and Health Administration (OSHA) or NIOSH exposure criteria for sub-radiofrequency (RF) fields. The American Conference of Governmental Industrial Hygienists (ACGIH) has published Threshold Limit Values (TLVs) for sub-radiofrequency electric and magnetic fields (30 kilohertz [kHz] and below). The TLV for sub-radiofrequency magnetic fields (B_{TLV}) states that occupational exposure from 1 to 300 hertz (Hz) should not exceed the ceiling value given by the equation:

$$B_{TLV} \text{ (in mT)} = 60/f$$

where f is the frequency in hertz. One millitesla (mT) equals 10 Gauss (G). For frequencies in the range of 300 to 30,000 Hz, occupational exposures should not exceed the ceiling value of 0.2 mT (2 G). These ceiling values for frequencies of 300 to 30,000 Hz are intended for both partial- and whole-body exposures. For frequencies below 300 Hz, the TLV for exposure of the extremities can be increased by a factor of 5.

The sub-radiofrequency electric field TLV states occupational exposures should not exceed a field strength of 25 kilovolts per meter (kV/m) from 0 to 100 Hz. For frequencies in the range of 100 Hz to 4 kHz, the ceiling value is given by:

$$E_{TLV} \text{ (in V/m)} = 2.5 \times 10^6/f$$

where f is the frequency in hertz. A value of 625 volts per meter (V/m) is the ceiling value for frequencies from 4 kHz to 30 kHz. These ceiling values for frequencies of 0 to 30 kHz are intended for both partial- and whole-body exposures.

This means, for example, at the power line frequency of 60 Hz, which is classified as ELF, the electric field TLV would be 25 kV/m and the magnetic field TLV would be 1 mT or 10,000 milligauss (mG).

The health and safety basis of the ELF electric field TLV is to minimize occupational hazards arising from spark discharge and contact current situations.

The magnetic field TLV addresses induction of magnetophosphenes in the visual system and production of induced currents in the body. Prevention of cancer is not a basis for either of these TLVs because exposure to ELF fields has not been conclusively linked to cancer.

METHODS

ELF Measurements

This evaluation was designed to assess occupational exposure to sub-radiofrequency fields in the range from 40 to 800 Hz on workers during a typical daily work regiment. The number and types of measurements performed in this evaluation were not intended to represent an in-depth investigation of exposure to all electric and magnetic fields present in the building, but are intended to estimate occupational ELF exposure levels from selected sources on the days of measurements.

The following equipment was used in this evaluation:

◆ Magnetic field measurements were made with the EMDEX II exposure system, developed by Enertech Consultants, under project sponsorship of the Electric Power Research Institute, Inc. The EMDEX II is a programmable data-acquisition meter which measures the orthogonal vector components of the magnetic field through its internal sensors. Measurements can be made in the instantaneous read or storage mode. The system was designed to measure, record, and analyze power frequency magnetic fields in mG in the frequency range from 40 to 800 Hz. The meter has the capability of displaying magnetic field values in three different frequency bandwidths: broadband, which measures from 40 to 800 Hz; harmonic, which measures from 100 to 800 Hz; and the fundamental bandwidth, which measures at 60 Hz.

◆ A Holaday Industries, Inc. model HI 3602 ELF sensor, connected to a HI-3600 survey meter, was used to document both the magnitude of ELF electric

and magnetic fields as well as the waveforms produced by these fields. The electric field strength was measured in V/m and the magnetic field strength was measured in mG over the frequency range from 30 to 800 Hz.

◆ AMEX-3D exposure meter manufactured by Enertech Consultants. This small, lightweight three-axis magnetic field meter can either be worn by a worker or attached to objects. The meter stores an electric charge, proportional to the time-integral of the low-level magnetic field, which is then read and converted into average magnetic field values.

In performing this evaluation, the NIOSH investigators utilized data obtained from measurements made at the following locations: (a) on a random sample of fixed locations within the CMCBT building; (b) from all four employees who worked in the Tax Office; and (c) on a random sample of fixed locations outside the CMCBT building.

Fixed Location Field Measurements in the Building

Magnetic field data for this part of the investigation was obtained in selected areas of the Tax Office by mounting AMEX dosimeters to walls at a height of four feet from the ground. A total of six AMEX dosimeters were used and each operated over approximately two hours.

Electric and magnetic field measurements also were made at waist level in walkways, maintenance areas, and various office and building rooms located in the Hall of Records, Tax Office, and the utility room. Approximately 50 such measurements were made for this portion of the evaluation.

An EMDEX meter was used to obtain estimates of the magnetic fields present near a desk located in the back area of the Tax Office. The meter was placed in a bottom desk drawer located next to the rear wall—closest to the utility room. This measurement was to simulate the occupational exposure that might have been obtained from a worker sitting at that

desk.

Personal Field Measurements for Employees in the Tax Office

EMDEX dosimeters were put on all four Tax Office workers over a two day period. Three workers were monitored the first day and two workers were monitored the second day. One worker was sampled on both days. The first day data was taken in the broadband mode only, while the second day data was acquired in broadband, harmonic, and fundamental modes. The use of the three frequency bandwidths was to confirm the presence and dominance of power line frequencies in the Tax Office. The EMDEX units were worn around the waist in special sashes provided by NIOSH and each worker was instructed not to wear the unit out of the building. If they had to leave the building, they were told to leave the dosimeter on their desk.

Fixed Location Field Measurements Outside the Building

Electric and magnetic field measurements were made at all entryways immediately outside the building, in the paved area immediately in front of the building, and in the parking lot on two different days. Measurements were also made at the corners of the building.

Medical Interviews

All four Tax Office employees were interviewed by a NIOSH medical officer. During these interviews, employees were questioned about possible medical problems and work history.

RESULTS

ELF Measurements

Fixed Location Field Measurements in the Building

The six AMEX dosimeters, which were placed next to such office sites as desks and work tables, measured magnetic field levels ranging from 0.2 to 3.0 mG. AMEX dosimeters were not placed in the rear of the Tax Office. Electric field measurements made at the locations of the AMEX dosimeters ranged from 2 to 4 V/m.

A total of 50 measurements were made at various locations to determine if unusual exposure sources existed within the building. Magnetic field levels ranged from 0.1 to 10 mG and electric field levels ranged from 2.0 to 4.6 V/m in the Hall of Records. The highest magnetic fields in the Hall of Records were found along the back rear wall, a portion which was adjacent to the utility room.

A series of measurements with one EMDEX meter, set to measure at 1.5 second intervals and used in a walk-around mode, were made in the Tax Office at seven different locations near desks and worktables, as a function of height above the floor. The data collected in this manner is shown in Table 1. The rear area had much higher magnetic fields than other areas of the Tax Office.

Another set of measurements were made by leaving an EMDEX meter running overnight at a desk to simulate a worker's position prior to their movement to a new location outside the back area. The meter operated for 15 hours, measuring an average magnetic field level of 47.2 mG. This was repeated on the second day, but for only two hours, and showed an average level of 70.4 mG. The difference between the two readings is probably due to reduced electrical consumption (loading factors) at nighttime.

Finally, to confirm that the magnetic field present in

the back area of the Tax Office was associated with the four switchboards located in the utility room, and to compare our results with earlier measurements, a series of measurements were made every two feet (2') along the back wall at a height of 4' above the floor. This information, shown in Table 2, shows that at 8' from the west wall a maximum occurs that had ranged from 175 to 1200 mG over time. NIOSH investigators made measurements at a location in front of the switchboard units and about two meters from the back wall of the Tax Office, as a function of distance from the west wall. The value at 8' was 230 mG; the highest level for any of the distances measured. The fact that the maximum occurred at 8' from the wall in two different measurement areas strongly implicates the switchboard units are the electrical source responsible for the high magnetic fields in the back of the Tax Office.

Personal Field Measurements for Employees in the Tax Office

The information obtained from the EMDEX units all worn at the worker's waist position over the two days of sampling, is shown in Table 3. The mean magnetic field levels from the three workers who wore the EMDEX II units on the first day ranged from 7.6 – 33.6 mG. The first day's data was collected in a broadband mode every 1.5 seconds. The data collected on the second day was collected to show the broadband, harmonics, and fundamental modes. Only two workers were sampled the second day and their mean magnetic field levels ranged from 3.0 to 11.4 mG (broadband) and 2.7 to 11.1 (fundamental). The finding that the broadband component is almost equal to the fundamental component suggests that exposure is mainly from power line frequencies (60 Hz).

The highest magnetic field was recorded on the first day on a worker who spent the majority of the work day in the back area of the Tax Office. The same worker was measured the second day and was exposed to about 50% of the average exposure for the first day. On the second day, the worker spent most of the workday in the front area of the office. This demonstrated the magnetic field impact that the

four switchboards in the utility room had on the environment of the back area of the Tax Office. The large variance in the values of the standard deviation suggests movement of the workers. It should also be noted that interviews were held with the various workers in the rear office which may account for the magnitude recorded by the workers who did not occupy or work in the back area.

Fixed Location Field Measurements Outside the Building

Levels outside the Tax Office and immediately next to the outside wall were in the 1 to 3 mG region. The only exception to this were magnetic levels measured at the outside back corner of the Tax Office, closest to the utility room where the switchboard equipment was located, where levels were as high as 25 mG. The highest electric field measured anywhere over the two day period on the outside of the building was 5 V/m.

Measurements were also made in a small bricked area in the courtyard located about 15' from the Tax Office that housed two small transformers used to deliver electrical power to another building. Levels inside the bricked off area gave higher (100 to 300 mG) magnetic field levels but were not of occupational concern due to low occupancy factor for workers and the distance from the Tax Office. The area had a gate but it was not locked.

Medical Interviews

The four Tax Office workers ranged in age from 30 to 45 years of age; three were female. All of the employees had worked in the Tax Office for at least two years. Two of the four workers reported non-malignant breast problems. One reported a non-malignant thyroid problem and the other an abnormal cervical pap smear test. The NIOSH investigators could not find any reports in the scientific literature that associate these medical conditions with exposure to ELF fields.

DISCUSSION

Measurement Results

Tables 1 and 2 show the measurement data obtained from this evaluation by type of measurement and location. These data suggest that the range of ELF electric and magnetic fields measured both inside and outside the CMCBT building are generally low, approximately the same magnitude reported previously by the electrical utility company and one of the affected workers, generally within the range of exposure levels in office settings measured by NIOSH investigators in previous evaluations, and well below current occupational exposure limits. It was conclusively shown from measurements made by NIOSH, and supported from results of other measurements, that the dominant magnetic field exposure was due to power line frequencies which are produced by the four switchboard units located in the utility room—behind the north wall in the back area.

The magnetic field levels measured in the back area of the office were somewhat higher than those in other areas of the office. Although employees may be concerned about ELF exposure even at levels below current occupational limits, there is currently no conclusive evidence to show that chronic exposure to power frequency fields causes adverse health effects. It should be noted, however, that research suggests that health effects related to ELF fields may be linked to many variables, of which field strength is only one. There are no reports in the scientific literature that associate the health effects reported in this evaluation with ELF exposure.

Video Display Terminal Screen Distortion

Sensitivity of electronic devices, such as a video display terminal (VDT) monitor, to electromagnetic fields does not necessarily mandate concern about human health effects. Quite often electronic sensitivity level, or electromagnetic interference (EMI) issues, can occur at levels which are orders of magnitude below adverse health effects levels.

NIOSH has found in several previous evaluations that VDT monitors are affected by unwanted magnetic fields. In fact, initial concern about the presence of ELF fields in the Tax Office was created when it was observed that screen images on a VDT were distorted the closer they were to sources of power line frequencies. Similar screen problems have been reported to occur at magnetic field levels as low as 100 mG in other NIOSH evaluations.

“Non-Essential” ELF Exposure

Sources of ELF field exposure were prevalent throughout the CMCBT building. NIOSH investigators observed a wide range of items contributing to total ELF magnetic field exposure. Many items, such as VDTs and photocopy machines, are essential to the modern office environment. Others, however, could be considered “non-essential” and their presence should be re-evaluated by employees concerned about their overall exposure to ELF electric and magnetic fields. Electromagnetic field strength decreases in proportion to at least the square of the distance from the source. Thus, while “non-essential” sources in an employee's own work space may be relevant to his or her total exposure, such sources in a neighbor's work space should be of much less concern. These sources included the items listed below.

electric clocks	various electric lamps
surge protectors	AM/FM radios
microwave oven	laser printers
electric space heaters	electric calculators
FAX machines	photocopy machines
power strips	VDTs
small electric refrigerator	coffee pot
electric pencil sharpeners	dictaphones
microfiche machines	electric typewriters

While measurements were not made exclusively on all of the above sources in this evaluation, results from previous NIOSH evaluations and other studies have clearly shown that very high localized magnetic field levels exist in close proximity to these types of sources. In fact, the magnetic field levels from these sources at close distances are orders of magnitude

higher than what is reported in this evaluation for the average magnetic field levels. It should be kept in mind, however, that workers do not normally remain near such sources for long periods of time and that the magnetic fields do tend to fall off quickly as a function of distance from the source. This suggests that overall exposure contribution from these sources should be small. Nevertheless, the elimination of many of these non-essential sources from the workplace would produce some reduction in ELF fields.

Controlling ELF Exposure

The use of shielding material is often suggested as a technique for controlling occupational exposures to various physical agents. Unfortunately, shielding of magnetic fields in the power line frequency range is not very effective since they can pass through most common objects without being significantly affected. The two best methods to reduce magnetic field strengths are to limit the worker's time of exposure and to increase the distance between the source and worker.

In this evaluation, one possible technique to control

the higher magnetic field levels in the back area, assuming movement of the switchboards to a distance further from the back wall is not possible, would be to designate the back area as storage.

CONCLUSIONS

The NIOSH investigators were able to determine that the ELF electric and magnetic field strength levels, both inside and outside the CMCBT facility are generally low, the fields inside are approximately the same magnitude measured previously by the electrical utility company and by one of the affected workers, the magnetic field levels in the back area of the Tax Office are at the higher end of the exposure level range documented in previous NIOSH evaluations, and all levels were below the current occupational exposure ceiling limit of 10,000 mG recommended by ACGIH. At this time it is not possible to conclude, based upon current scientific and medical knowledge, that the reported health effects are linked in some way to ELF exposure. As with many occupational exposures, however, employees or employers may wish to reduce them even if they do not exceed current limits.

Table 1
Results of EMDEX Sampling in Tax Office
as Function of Height Above Floor
Cape May County Board of Taxation
Cape May Court House, New Jersey
HETA 94-0300

EMDEX Location	Range of Magnetic Field Levels (expressed in milligauss [mG])
<i>Front and Middle Office Areas</i>	
Ceiling height	1.3 to 10
Desktop height	1 to 1.5
Floor height	0.8 to 4
<i>Back Area (near Utility Room)</i>	
Ceiling height	15 to 40
Desktop height	20 to 50
Floor height	18 to 30

Table 2
Comparison of Various Magnetic Field Measurements in Back Area
of Tax Office Over Time
Cape May County Board of Taxation
Cape May Court House, New Jersey
HETA 94-0300

Distance from corner of west wall at rear of Tax Office (feet) (4' off floor)	Magnetic field levels before full activation 2/10/93 by local power company (mG)	Data reported by worker (expressed in milligauss [mG])				Magnetic field levels after full activation 10/20/93 by local power company (mG)	NIOSH data 9/15-16/94 (mG)
		3/5/93	3/17/93	3/26/93	9/27/93		
2	24	28	43	57	86	78	75
4		213	241	324	675		400
6		290	316	456	905		500
8	175	455	447	678	1200	704	700
10		397	416	565	1125		600
12		340	332	480	928		600
14		157	160	248	435		320
16		32	31	30	92		130
18	31	18	21	26	62	45	40

Table 3
Magnetic Field Results Obtained from EMDEX Units at CMCBT
Cape May County Board of Taxation
Cape May Court House, New Jersey
HETA 94-0300

	milligauss						No Samples	Collection Time		
	Minimum	Maximum	Mean	St Dev	Median	Geo Mean			St Dev	
<i>First day — 9/15/94</i>										
Worker 1*	0.9	168.9	33.55	33.20	31.1	15.54	4.38	5121	1.5 s	
Worker 2*	0.6	61.1	5.23	10.38	1.4	2.31	2.84	4645	1.5 s	
Worker 3*	0.9	37.3	7.62	7.37	5.3	6.06	1.77	3702	1.5 s	
<i>Second day — 9/16/94</i>										
Worker 1										
Broadband	0.6	398	11.43	16.87	2.5	4.47	4.12	3114	3.0 s	
Fundamental	0.1	391	11.11	16.73	2.2	3.77	4.82	3114	3.0 s	
Harmonic	0.3	67.3	2.00	2.45	0.9	1.36	2.21	3114	3.0 s	
Worker 4										
Broadband	0.3	336.1	3.02	12.64	2.0	1.91	1.83	3126	3.0 s	
Fundamental	0.1	329.3	2.71	12.53	1.6	1.58	1.97	3126	3.0 s	
Harmonic	0.2	67.3	1.07	1.80	0.9	0.89	1.68	2136	3.0 s	
Evaluation Criteria:	ACGIH						10,000		Note: This criteria assumes exposures to 60 Hz (power line frequency) and was intended to prevent induction of magnetophosphenes in the visual system and production of induced currents in the body. Prevention of cancer is not a basis for this TLV because exposure to ELF fields has not been conclusively linked to cancer.	

Comments:

* Broadband data only recorded.

St Dev = Standard deviation

Geo Mean = Geometric mean

